Seasonal Variation Analysis of Microplastic Distribution in the Estuary of Brantas River

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Abstract. Every year, 0.48-1.29 million tonnes of plastic waste is estimated to enter the waters due to poor plastic waste management in Indonesia. Plastic waste has the potential to be degraded into smaller particles through ultraviolet (UV) radiation, weathering process, water currents, physical-mechanical and biodegradation. Plastics with particle sizes between >1 µm and <5 are categorized as microplastics (MP). Microplastic particles are mainly distributed in surface waters. Rivers are considered as the main route of plastic transportation from the land to the ocean. The Brantas River in Surabaya is the main downstream section of the Brantas River and plays an important role in providing clean water for Surabaya City, aquatic biota habitat, and irrigation. With extreme weather conditions such as long dry seasons and high rainfall in the rainy season distribution and abundance of microplastics in water bodies/rivers tend to vary. The study's goal is to determine the effect of seasonal water volume (dry and rainy) on the abundance and characteristics of microplastics in water and sediment samples from the downstream Brantas River (Surabaya city). Observations of the abundance of microplastics in water and sediment at three stations during the dry season revealed a trend of increasing abundance downstream. Microplastics were abundant in the water at sta 1 with an average of 0.8 particles/L, sta 2 with 1.25 particles/L, and sta 3 with 1.02 particles/L. The abundanceof microplastics in the sediment at sta 1 averaged 0.2 particles/gr, sta 2 0.51particles/gr, and sta3 0.25 particles/gr. Meanwhile, in the rainy season, the abundance of microplastics in water and sediment shows a higher abundancecompared to the dry season. Abundance of microplastics in the water at sta 1 with an average of 0.9 particles/L, sta 2 1.24 particles/L, and sta3 1.17 particles/L. The abundance of microplastics in the sediment at sta 1 averaged
0.55 particles/gr, sta 2 0.56 particles/gr, and sta3 0.60 particles/gr.

Keyword : Brantas river, Downstream, Dry and rainy season, Microplastic

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1 Introduction

Around 0.48-1.29 million tonnes of plastic waste is estimated to enter global waters each year because of poor plastic waste management in Indonesia. The large use of plastic in various fields is also a factor in the amount of plastic waste generated [1]. Plastic waste can be degraded to smaller particles by physical, chemical, and biological processes and degradedinto small particles known as microplastics [2,3]. Microplastics are plastic particles with a size diameter between 1µm to <5mm [4].

Based on the source, microplastics are classified into two, namely primary microplastics, which are particles designes specifically for industrial applications and secondary microplastics, which are the result of the degradation of large-sized plastics or macroplastics [5]. Plastic waste can be carried by the flow of currents from the river to the estuary then to the sea and end up settling on the bottom of the ocean [6]. Microplastics that are ingested in organisms then undergo translocation to the organism's tissues so that they accumulate in body tissues and cause adverse effects, namely disruption of the organism's health, either a slowdown in growth or a disturbance in the digestive tract [7]. Rivers are considered to be a primary pathway for the transport of plastic waste from land to ocean [8]. Microplastics can be deposited in sediments along the river and will later accumulate in the estuary along with the flow of the river leading to the estuary. The occurrence of microplastics in waters can have a negative impact, one of which is the danger of microplastics can affect the level of the food chain [9].

Brantas River flows through 15 densely populated cities which serve as a source of irrigation and also the main water supply in East Java Province [10]. In East Java, about 32.5% of the population in some of these cities have established settlements within 500 m of the riverbank [11]. The Brantas River serves as an important river in East Java. The Brantas River has an area of 11,800 km² or ¼ of the area of East Java Province. Brantas River has very important benefits for East Java Province as a means of irrigation, drinking water raw materials, and industry. The Brantas River is one of the rivers whose flow passes through residential areas, factories, and mining, so these activities can cause waste to be discharged directly into the waters which can have a negative impact on water quality [12,13].

This research aims to determine the effect of water volume in the season (dry and rainy) on the abundance and characteristics of microplastics in water and sediment samples from the downstream Brantas River (Surabaya city).

2 Material and Method

2.1 Location and time of study

The research was carried out during the dry and rainy seasons of September and November 2022, with sampling locations in the Brantas River estuary. The microplastics analysis was conducted at The Ecology Laboratory, Department of Biology, Faculty of Science and Data Analysis, Institut Teknologi Sepuluh Nopember, The research station is shown below (Figure 1; Table 1).

Fig. 1 Research station in the Estuary of Brantas River.

Table 1. Coordinates of sampling station

Location	Coordinates
Station 1	7°19'53.6"S 112°42'27.5"E
Station 2	7°17’58.7”S 112°44’21.4”E
Station 3	7°13'27.4"S 112°44'17.3"E

2.2 Method

2.2.1 Water samplings

Water samples are gathered from the river and filtered through an 80 m mesh plankton net. The plankton net was cleaned from the mouth to the cod end. The resultsof the filtered are put in a sample bottle, preserved with 70% ethanol solution and tightly closed. Sample bottles were labeled to differentiate each sampling station and stored in a cool box for further analysis in the laboratory [14].

2.2.2 Sediment sampling

Sampling was collected using a bottom grab, and the sediment was filtered using a graded sieve with a mesh size adjusted for microplastic analysis. The filtered sediment samples were then placed in a container that had previously been labeled and placed in a cool box for further analysis in the laboratory [15].

2.2.3 Preparation of microplastics in water sample

Water samples obtained from the research site were transferred into beaker glass, and continued with the destruction of organic matter using 30% H2O2. Next, it was stored in a container for 24 hours and covered using aluminium foil and incubated in a waterbath at 75°C for 24 hours. After the solution looks clear, filtering is done using Whatman grade 42 filter paper with a pore size of 2.5 µm. Filtering was carried out by vacuum filtration, namely using a buchner funnel filtering tool that was given filter paper [6].

2.2.4 Preparation of microplastics in sediment sample

Sediment preparation began with drying the sediment using an oven at 75°C. Next, the sample was transferred to a glass beaker/ erlenmayer and concentrated NaCl (1.15-1.13 g L-1) was added using a ratio of 1:3 between sediment and NaCl solution [16,17]. After obtained natan and supernatant, the sample was separated with the supernatant added 30% H2O2 and incubated in the oven for 24 hours and filtered the sample using Whatman grade 42 filter paper with a pore size of 2.5 μm [18,15].

2.2.5 Characteristics analysis of microplastics

Microplastics that have been filtered and dried on filter paper (water and sediment samples) were observed physically/visually by the abundance of microplastics, observing the shapes and color, and measuring the size of microplastics. Physical observations were made with a stereo microscope. Microplastic size was measured using optilab viewer software to facilitate measurement and observation. In determining the shape and color of microplastics, identification guidelines for the color and shape of microplastics from the literature were used. After physical identification of microplastics, observation data were recorded in the prepared data observation [19].

2.2.6 Data analysis

This study examined the characteristics of microplastics in water and sediment samples using descriptive quantitative analysis by comparing the abundance of microplastics in water and sediment samples, identifying the types of microplastics found in water and sediment samples, accumulating the colour of microplastics and sorting the size of microplastics found in water and sediment samples from different seasonal variations in the Brantas River.

3 Result and Discussion

3.1 Microplastic abundance in water and sediment samples

Based on data from the observation of microplastics in water samples, it was found that average of abundance microplastics from 3 stations in the research location (Figure 2), there was an increase in microplastic abundance at each station in different seasons. At station 1, the average abundance of microplastics in the dry season was 0.80 particles/L and increased to 0.9 particles/L in the rainy season, station 2 in the dry season was 1.25 particles/L and 1.24 particles/L in the rainy season, station 3 in the dry season was 1.02 particles/L and increased to 1.17 particles/L.

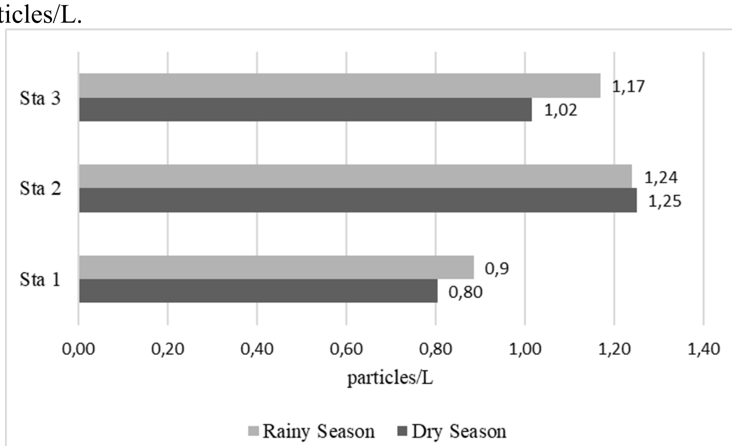

Fig. 2 The average abundance of microplastics in water samples at dry and rainy seasons

Microplastics obtained in the estuary of the Brantas River are assumed to be caused by anthropogenic activities that occur around the river. The abundance of microplastics is higher in urban areas that are densely populated because the abundance of microplastics is closely related to the population [6]. The distribution of microplastics in waters is influenced by currents, wind, tides, river hydrodynamics, and uneven contamination of the environment.

Microplastics that have low density will float in water bodies, while high-density microplastics sink to the bottom of the surface [20].

Other than in water samples, microplastic contamination was found in sediments from 3 research stations in the Brantas River. The average abundance of microplastics from three stations near the research site was obtained (Figure 3); the average abundance of microplastics at station 1 in the dry season was 0.20 particles/g, station 2 0.51 particles/g, and station 3 0.25 particles/g. Meanwhile, in the rainy season, the results showed an average higher than the dry season abundance of microplastics in sediment samples where station 1 was 0.55 particles/g, station 2 0.56 particles/g, and station 3 0.60 particles/g.

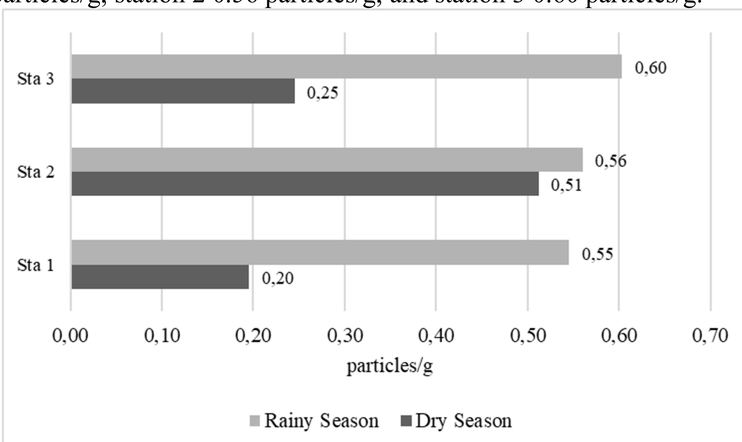

Fig. 3 The average abundance of microplastics in sediment samples in dry and rainy seasons

Based on the graphic (Figure 1 and 2), it is evident that there was an increase on the abundance of microplastics in the rainy season. The occurrence of plastic waste can be carried by the flow of currents from the downstream area of the river to the sea [21], and high rainfall increases the volume and discharge of water in the river flow can affect the distribution of microplastics in the waters, because water flow affects the movement of microplasticparticles [22,23]. The high number of particles and abundance of microplastics in sedimentsis thought to be due to the influence of gravitational forces, current and wave movements, and density. Microplastics will settle in the sediment if the density of the water is lower thanthe density of microplastics [24].

3.2 Microplastics types in water and sediment samples

Based on the results of observations that have been done, 4 types of microplastics were obtained from water and sediment samples, namely Fragments, Fiber Film, and Bead (Figure 4a and b), from the results of the calculation of microplastic particles based on the microplastic form, the dominant type of microplastics in water samples from 3 stations is fragments and fiber with percentages ranging from 38-73% in the dry and rainy seasons. Other than fragments, the dominant type of microplastic was found in fiber with a percentage ranging from 20-53% in the dry and rainy seasons (Figure 4a). The results of microplastics obtained in sediment samples showed a dominance in the type of fragments and fiber. In the type of fragments ranges from 46-74% while in the fiber ranges from 25-35% (Figure 4b).

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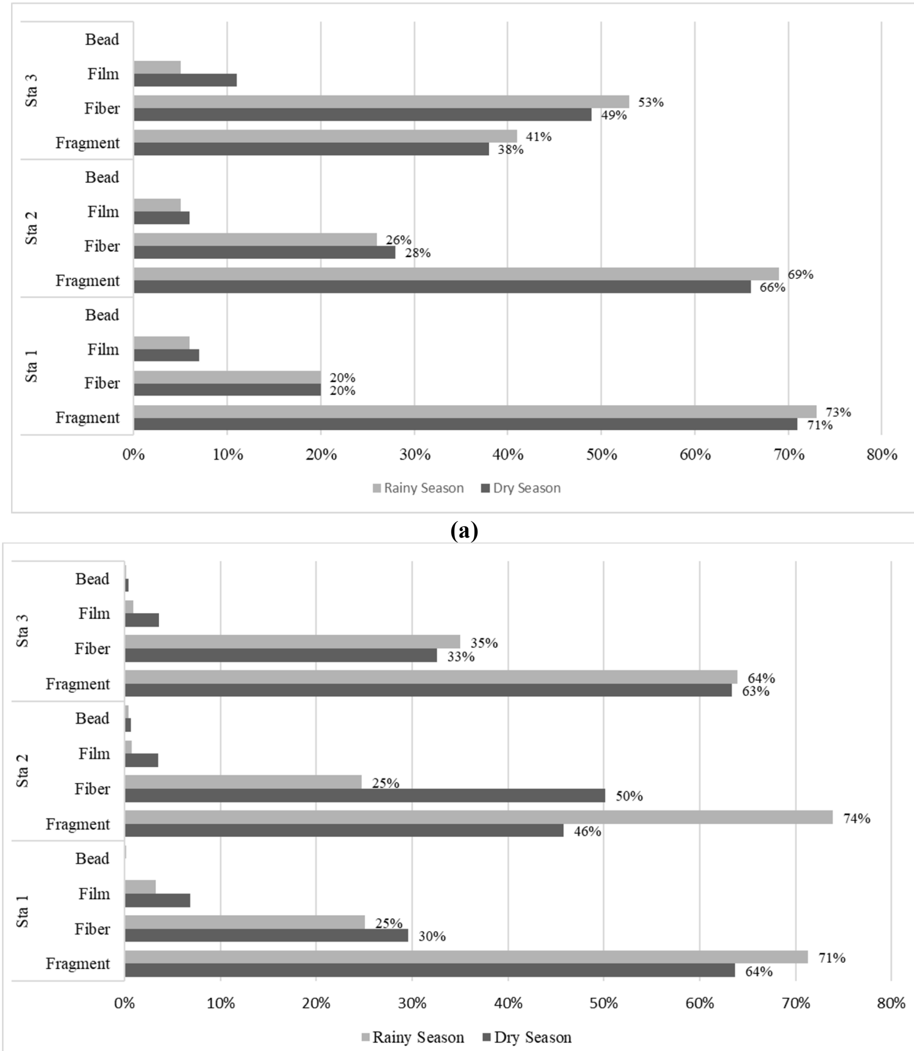


Fig. 4 Percentage types of micoplastics in (a) water samples and (b) sediment sampels at dry and rainy season

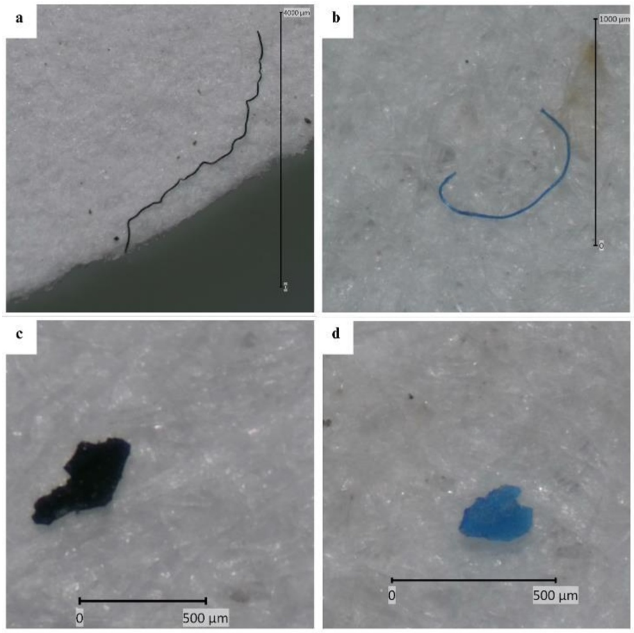
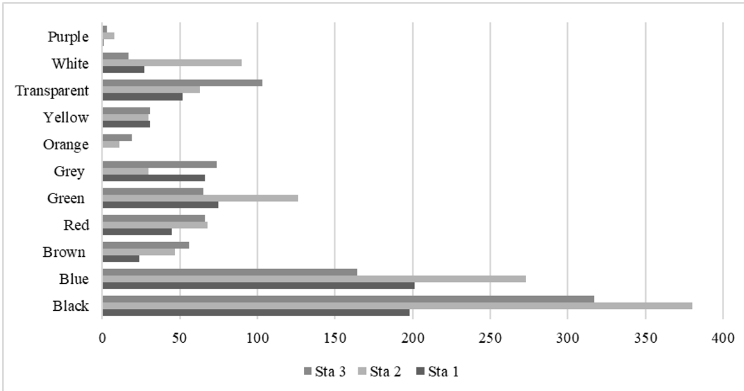


Fig. 5 Dominant types of micoplastics in water and sediment samples at Estuary of Brantas River (a-b) fiber, (c-d) fragment

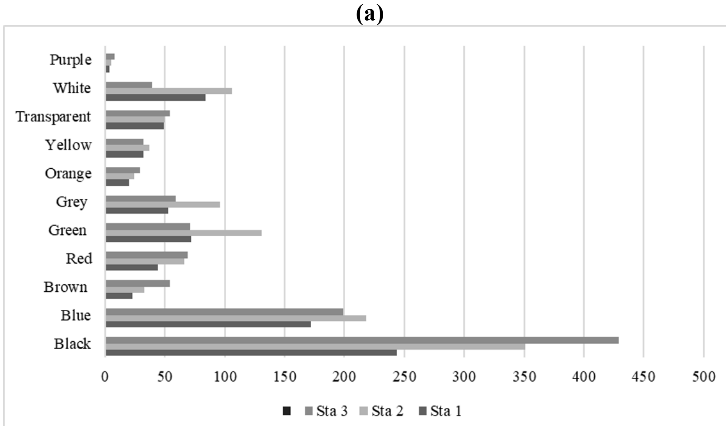
Microplastics type fragment could be caused by the degradation/fragmentation of plastic food and beverage packaging, as well as wood chips from fishing boats or fishing equipment fragments exposed to UV light, so that they become brittle and form smaller microplastic particles [25]. Fiber type assumed is derived from fishing gear, fishing nets, floating net cagenets, textile fibres, and household waste [26]. Film type are thought to be formed due to fragmentation of plastic pieces that have a very thin layer in the form of sheets such as plasticbags that have a low density. Bead type could have been produced from the remaining raw materials of industrial activities such as toiletries, shampoo, toothpaste, soap and facial cleansers [27].

3.3 Microplastics colours from water and sediment samples

Field research found 11 different colors of microplastics in water and sediment at the three research stations: black, blue, brown, red green, grey, orange, yellow, transparent, white, and purple (Figures 6 and 7). There is no difference in color dominance in water and sediment samples influenced by season, from all microplastic data found, the dominant colors of microplastics are blue and black.

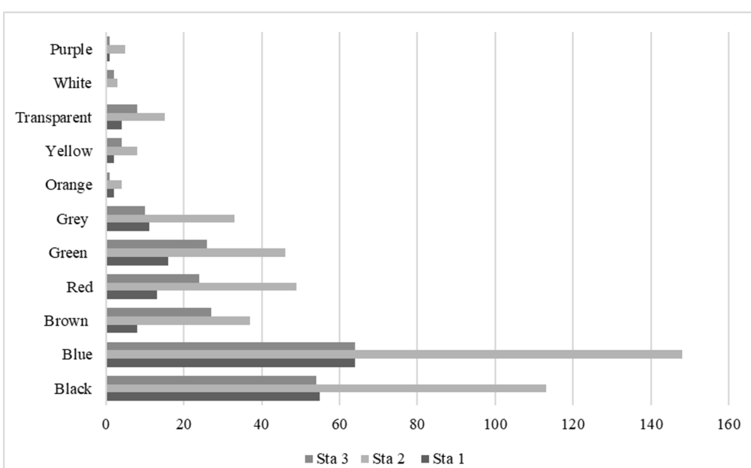


(a)

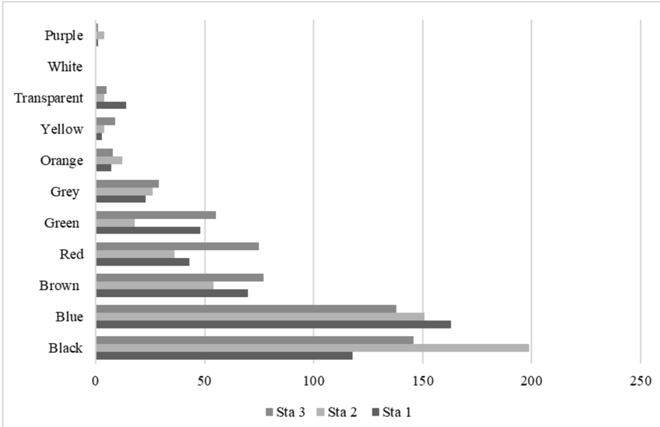


(b)

Fig. 6 The dominant color of microplastic discovered in water samples during (a) the dry season and (b) the rainy season



(a)



(b)

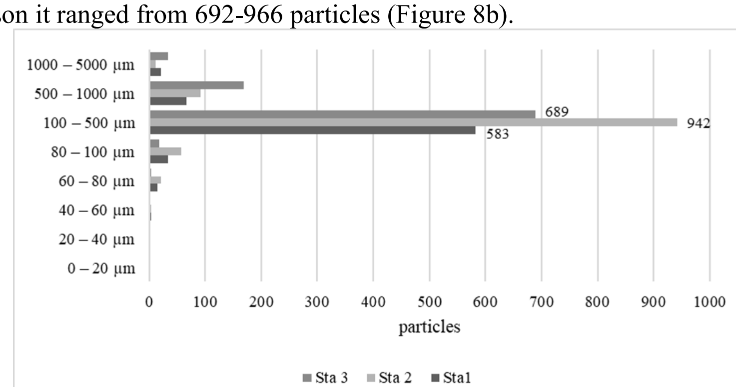
Fig. 7 The dominant color of microplastic discovered in water samples during (a) the dry season and (b) the rainy season

The varied colors of microplastics may be caused by the activities of people who distribute various kinds of plastics. The color difference in microplastics is thought to occur due to the length of time the microplastics are exposed to sunlight [24]. Exposure to UV light causes discoloration of plastic particles, the longer the exposure time affects the color of the plastic which changes at first the plastic turns into a light color (discoloration), then the pigment is lost in the microplastic so that it changes color to white/transparent, and yellowing of the microplastic (yellowing) [28].

3.4 Category of microplastic size in water and sediment samples

Microplastics collected in this research were observed using optilab viewer software and measured using image raster 3 software. In this research, microplastics were classified based on size into 8 groups by Nor & Obbard [29], 1) 0 - 20 µm, 2) 20 - 40 µm, 3) 40 - 60 µm, 4) 60 - 80 µm, 5) 80 - 100 µm, 6) 100 - 500 µm, 7) 500 - 1000 µm, and 8) 1000 - 5000 µm.

The domination of microplastic abundance based on the same size from each station in water samples in the dry and rainy seasons was found in the size categories with a range of 100-500 µm (Figure 8a and b). The abundance of microplastics with a size range of 100-500 µm from stations 1-3 in the dry season ranged from 583-942 particles (Figure 8a), while in the rainy season it ranged from 692-966 particles (Figure 8b).



(a)

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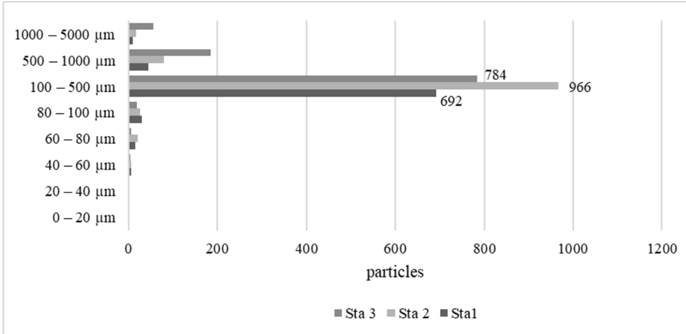
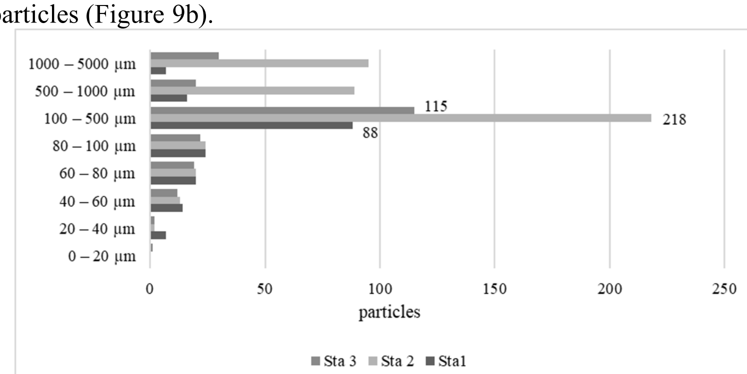


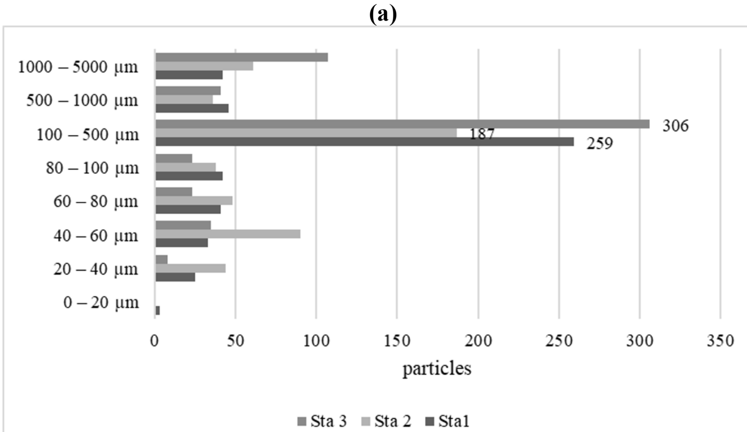
(b)

Fig. 8 The domination size categories of microplastic in water samples at (a) dry season and (b) rainy season

Other than the water samples, the dominant size-based abundance of microplastics in sediment samples in the dry and rainy seasons was found in the size range of 100-500 µm (Figure 9a and b). With an abundance of 100-500 µm microplastics from stations 1-3 in the dry season ranging from 88-218 particles (Figure 9a), while in the rainy season ranging from 187-306 particles (Figure 9b).



(a)



(b)

Fig. 9 The domination size categories of microplastic in sediment samples at dry and rainy season

The variations of the size in microplastics that are found in water and sediment samples can be influenced by the fragmentation/degradation process in the waters, where if the longer the fragmentation occurs in microplastics, the possibility of microplastics with smaller sizes will be produced. Also, the more factors that affect the fragmentation/degradation process, it can cause microplastics to experience a faster size reduction process. Some of them include UV light, water waves, enzyme compounds from microorganisms, and the presence of pollutants [26]. The presence of microplastics with a relatively small size can be the subject of interaction with aquatic organisms, because the smaller the particle size, the higher the possibility of being ingested and stored by organisms.

4 Conclusion

Based on the research, there were differences between the abundance of microplastics in the dry season and the rainy season. Seasonal differences can affect the abundance of microplastics in the waters, the abundance of microplastics in water and sediment in the dry season at 3 stations with an average abundance of microplastics in the waters at sta 1 0.8 particles/L, sta 2 1.25 particles/L, and sta3 1.02 particles/L. The average abundance of microplastics in the sediment at sta 1 0.2 particles/gr, sta 2 0.51 particles/gr, and sta 3 0.25 particles/gr. Meanwhile, in the rainy season, the abundance of microplastics in water and sediments shows a higher abundance compared to the dry season. Average abundance of microplastics in water at sta 1 0.9 particles/L, sta 2 1.24 particles/L, and sta3 1.17 particles/L. In sediment sta 1 0.55 particles/gr, sta 2 0.56 particles/gr, and sta3 0.60 particles/gr.

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